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5. Colonies of *Aglaophenia* sp. showing (a) terminal extension of stem; (b) terminal hook; (c) clasping of hooks; (d) budding of hooks; (e) new colony attached to side of jar and to parent stock.
6. Clasping hooks, magnified.

ANTIDROMY IN PLANTS.

By G. Macloskie.

In November, 1893, I published observations on Maize, from which it appeared that there are two castes of this plant, the leaves of one reversing the arrangement of those of the other. I also traced this diversity to the arrangement of the minute leaves in the young embryo in the seed; thus in figures 1, 2, the first foliage-leaf has its right margin overlapping its left margin. In other seeds from the same ear the first leaf would have its left margin external. I further found that the grains arising on adjoining rows in the ear of corn are of different castes, and produce "antidromic" plants (that is, growing up in opposing curves), and that the same property belongs to all the Gramineæ.

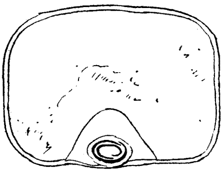

Fig. 1.
Grain of Maize; cross section.

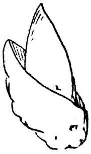

Fig. 2.
Young leaves of Plumule of Maize.

During the past summer I have extended this law so as to embrace the flowering plants. Every species is represented by two sets, differing antidromically as to the structure of the mother-seed, the stem, leaves and inflorescence. My attention was first attracted to this in the Ladies' Tresses (*Spiranthes præcox* Watson), which had, in some plants, dextral, in others sinistral, rows of white flowers; and on examination the dextral and sinistral anthotaxy were found to be accompanied respectively by dextral and sinistral phyllotaxy. Fig. 3, representing *Spiranthes aestivalis* Rich., shows, in a less crowded manner the sinistral anthotaxy[1] This specimen would doubtless have sinistrorse phyllotaxy, and there should be other specimens with dextrorse tresses and leaf spirals. Thus it appears that the much-belabored phyllotaxy of the old botanists is a special case of a larger subject. The homodromy of phyllotaxy and anthotaxy within a single individual may be observed in *Ænothera biennis, Verbascum thapsus, Laportea* and *Pontederia;* and even in *Gladiolus* and *Iris* we may trace a correspondence between the order of equitant leaves and the inflorescence. Whilst the produce of propagation by cuttings, buds, and bulbs is always homodromic with the parent stalk, some forms, like Calla-lily, Iris and Rush, when growing from division of a root-stalk, appear to be antidromic as if produced from different seeds. Fig. 4 shows the spathes of two Calla-lilies, from the same root-stalk, *d* having the dextral margin overlapping, and *s* having the sinistral overlapping. We may add that the akenes on the spadix of *d* make a dextrorse spiral, and those on that of *s* make a sinistrose spiral.

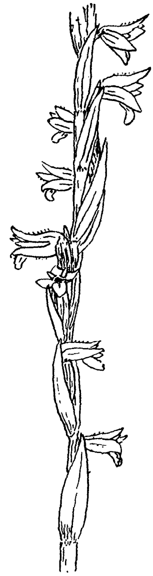

Fig. 3. *Spiranthes aestivalis* Rich., after Engler and Prantl.

In this connection it is interesting to observe that (so far as I am able to determine from leaves of *Bryophyllum* supplied me by Amherst Agricultural Station) the buds growing on opposite margins of the leaves are relatively antidromic.

Secondary changes, due to twining of stems, spreading out of leaves under the light, opposition of leaves, and crowding of flowers, and perfect symmetry of seeds, often disguise the primitive character, especially in the Dicotyledones. But, even in these cases, we commonly find some trace remaining. In the great majority of plants, in fruit trees, garden flowers and weeds, the phyllotaxy immediately divides the representatives of every species into a right-handed and a left-handed caste; and even when sunlight interferes, we often get help from

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[1] Dextral and sinistral in this connection signify in the direction, or against the direction, of the thread of a common screw.

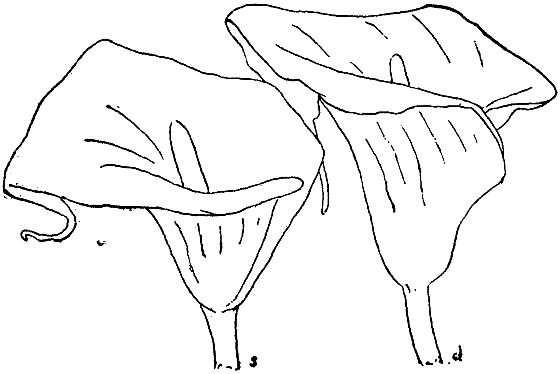

Fig. 4.—*Richardia africana* Kunth.

branches in the shade. Examples of it abound in all the more important orders of plants, and there seems to be no exception, though in opposite-leaved forms the evidence from phyllotaxy is not easily available. I have found no case of heterodromy as between the true foliage leaves of an individual plant; and the only case in which I have failed to observe antidromy between different plants is the Canna, which is mostly propagated by bulbs. (Doubtless there are specimens with a right-handed twist of the young leaves, though I have failed to find any.) In a bed of *Lily of the Valley*, half of the specimens have the inner leaf diverging 120° to the right, and the rest have similar divergency to the left. (Fig. 5.) In this, as in other Liliaceæ, the anthotaxy will be found to vary in harmony with the phyllotaxy.

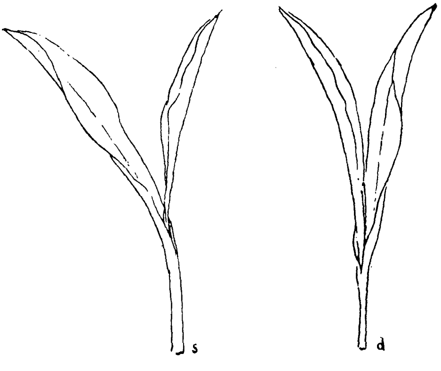

Fig. 5.

Doubtless the antidromic phyllotaxy causes a corresponding antidromy of the leaf-traces, and of structure of the stem. This has escaped anatomists who expected symmetry; but some of the figures in the books show a trending of leaf-traces to one side, and in all such cases we may be certain that some of the individuals have similar trending to the opposite side.

The structure of the embryo, and of the seed as conforming to the embryo, is very closely identical with that of the adult plant, and is of use to us when the other evidence is hidden. Thus fig. 6 shows the flat surface of a coffea-akene; half of the akenes are of this pattern, the other half resemble the image of this in a mirror. Fig. 7 shows a cross-section (*r*) of fig. 6; and also (*l*) of the antidrom of fig. 6, under the same orientation, and thus revealing the reverse order of the infolding of the endosperm. Fig. 8 presents the seed and embryo of *Nelumbium;* on seeing this I predicted the existence of other seeds with the embryo facing the opposite way, and promptly Mr. Barney and myself fished out of the Lily-ponds of Springfield, Mass., plenty of seeds which showed, under similar orientation, the embryos facing some one way and some the opposite way. The petals of Water-lilies are also diversely enfolded in the bud of different plants. The seeds of Lima-bean were found to have characteristic differences in the mode of enfolding upon each other of the first two foliage-leaves; and all the seeds growing on one valve of the pod were of one character, whilst those growing on the other valve were the antidroms of the former. The germinating pea sends up its plumule with a slight twist to one side or the other. The embryo of Basswood, with its large 5-lobed cotyledons, shows antidromic twists as between different seeds; and diversity is seen in the

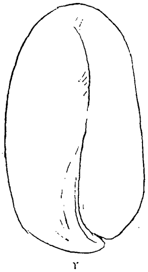

Fig. 6.

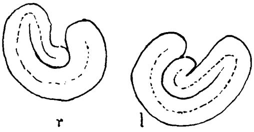

Fig. 7.

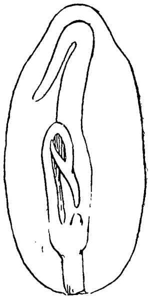

Fig. 8.

mode of folding of the embryos of the two seeds, produced by one flower, of Maple (*A. platanoides* L.). In Horse-chestnut the radicles of different seed incurve antidromically (*a* and *c* of fig. 9), and the young leaves of the plumule (situated inside the radicle at *p* of fig. *a*, enlarged at fig. *b*) show the leaflets differently arranged at the two sides, indicating the same primitive torsion as in other plants. The torsion of the plumule of *c* would be antidromic as compared with that figured.

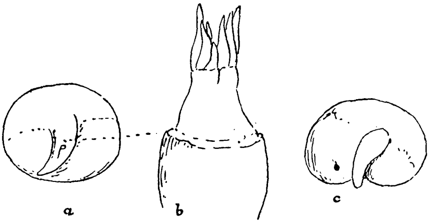

Fig. 9.
Embryo and Plumule of Horse-chestnut.

That the place of origin of the seeds is ordinarily the determining cause of this character is proved by Corn, Coffee, Bean, Lepidium, and other seeds. In Gymnosperm the bilateral origin of the seeds, and the spiral arrangement of their numerous cotyledons point to the same inference, which is confirmed by the phyllotaxy, and by the primary spirals formed by the scales of their cones, as well as by the lateral bending of their woody tissues. We may ascribe to this cause the habit of splitting of tree-trunks in contrary spirals, and I think that the same tendency sometimes shows itself in the sculpturing of the cortex, so that from the bark of Chestnut and hard-barked Hickory I can infer the direction of the phyllotaxy without seeing the leaves.

Direct evidence as to the Convulvulaceæ is difficult because of secondary distortions. But indirect evidence is available. Morning-glory has an incumbent curvature of the embryo as in many Cruciferæ, indicating such a diversity between the two seeds in a locule as produces in Cruciferæ antidromic phyllotaxy. This may also help to explain the twist of the embryo of *Lepidium virginicum* L. which has puzzled botanists, and if our surmise is good, we may expect to find the embryos of two seeds of the same fruit antidromically twisted.

After writing as above I examined the seeds from the two carpels of a flower of *L. virginicum,* and found them antidromic. The same explanation applies to the embryo of *sisymbrium officinale,* and to the spirally-folded embryos of *Chenopodiaceæ.* The two forms of the embryo of *Salsola kali* are figured in Engler and Prantl's Pflanzenfamilien (III, 1a, p. 84, Y, Z). The pods of mesquit (*Prosopis*) and of *Impatiens* have a right or left twist in harmony with the antidromic phyllotaxy of the plant on which they grow.

These observations help to solve old problems, recall phyllotaxy to the science in an improved garb, open up new lines of research, and start curious problems about heredity. If, however, the ovum is able to transmit the secondary characters of a species, there will be small difficulty found in admitting that it can transmit the primitive characteristics that are common to all Phanerogams, and that possibly belong also to the higher Cryptogams. But the curious point is the difference of heredity as between the two sides of a carpellary leaf; and other problems are started by such cases as Richardia. I wish to explain that my work has been necessarily done in haste, and whilst, as a whole, I think it is sound, it will doubtless need rectification in details.

POSTSCRIPT.—In the above I have unfortunately overlooked the valuable observations of Prof. W. J. Beal on *Phyllotaxis of Cones,* published in the AMERICAN NATURALIST of August, 1873 and March, 1877. He found the cones of individual spruce and larch trees to be heterodromic. If this should prove to be general or frequent, it may possibly be accounted for by secondary torsions during growth. My own observations on *Tsuga, Pinus,* etc., favor the view given above; and I may add that the arrangement of florets in heads of sunflowers and other compositæ appears to be antidromic and in accord with the phyllotaxy of the respective plants.

The cones of coniferæ change in opening so as to make the secondary spiral appear the dominant one. I have a cone of *Picca excelsa,* with ten scales open on one side, where they appear dextrally arranged, whereas the unopened side shows the primary arrangement to be sinistral. Taking the opened and unopened cones of the whole tree, one might conclude that half the cones were antidromic to the others.—G. M.